

Response to Final Editorial comments:

Investigating hydroclimatic impacts of the 168-158 BCE volcanic quartet and their relevance to the Nile River basin and Egyptian history

Singh et al. 2022.

We are grateful to all reviewers and editor for their valuable time, comments and suggestions for improving the manuscript. We believe these have helped us further improve the manuscript. The responses to the editorial corrections are in bold and text added to revised manuscript is in italics.

Comments: -

L19: “strato-volcanic”: here I think you mean to refer to eruptions that inject sulfur to the stratosphere, but since stratovolcano is a kind of volcano, this can be confusing. I would suggest to remove the word.

Response: - we removed the word “strato” and now it read as “volcanic eruption”.

L48: Here you refer to the global total aerosol optical depth increasing from about 0.6 to 0.75 after the Pinatubo eruption, numbers which include tropospheric as well as stratospheric aerosol. It is probable that many readers will not recognize that the tropospheric component is included here, and since later analysis focuses specifically on stratospheric aerosol, I would suggest considering phrasing this sentence in terms of stratospheric aerosol alone.

Response: - Rephrased the sentence as suggested. (L48)

L116: “statistically significant”

Response: - corrected as suggested at line number 120.

L321: change to “ka”, i.e., lowercase “k” for “kilo”

Response: - corrected as suggested.

L322, and throughout: fig-> Fig.

Response: - corrected throughout the manuscript.

L331: simulated a global mean surface...

Response: - corrected. L336

L387: Since you've given the LW anomalies as positive values above, and report the net anomalies as negative numbers below, it would make sense to report the SW anomalies as negative values here.

Response: - corrected.

L441: Most of the observations reported by Russel et al. (1996) are from specific locations, while what you show in Fig. 6 is a global mean. This may limit the degree to which you can compare the two, which may be worth a comment.

Response: - We have added information in the sentence which highlights this important point while putting in a comparison for aerosol size. Given below. Line 453

“In comparison, R_{eff} after Pinatubo (1991) increased to $0.6 \mu\text{m}$ as observed at a number of specific locations reported by Russell et al. (1996), with that size sustained for approximately 2 years. By contrast, the model simulated global sulfate aerosol sizes for the three subsequent extratropical eruptions (E2 to E4) grew up to $0.3 \mu\text{m}$.”

L451: Not sure what you mean by “phase of” the Brewer Dobson Circulation here. To be picky, the BDC is a wave-driven circulation, so the aerosol heating changes in dynamics don't affect the BDC, they are superimposed upon it. So, I would suggest to edit down this sentence removing reference to the BDC.

Response: - We modified the particular sentence, and “phase of Brewer Dobson Circulation” is replaced by the more general “atmospheric circulation”. Line: 466.

L470: I would ask the authors to be careful here: was there really no increase in AOD in the SH, or was it only small compared to that of the NH? Some modeling studies have found increases in AOD in the opposite hemisphere around 10% of that of the hemisphere of eruption, which may be significant if the eruption is large enough.

Response: - Thank you for this comment. We have modified the sentence and mentioned the residual impacts noticed after the eruption E1 (in Fig 7A). Line: 478.

“However, the other three eruptions (E2, E3 and E4) in the high latitude Northern Hemisphere yielded an increased AOD primarily confined to that hemisphere, with the cross-equatorial AOD response maintaining the residual impact after tropical eruption E1.”

L491: I've only ever seen the term "Hovmoeller diagram" used to describe plots which plot an atmospheric variable as a function of longitude and time. Wikipedia suggests a more general definition, but says they are used to highlight the behaviour of waves. That does seem to be the goal of the first hovmoeller diagrams. See <https://www.e-education.psu.edu/meteo820/node/546>. I would suggest removing the reference here and throughout to avoid confusion.

Response: - Thank for pointing this out. We agree that Hovmöller diagram is basically designed to show the wave like pattern though longitude and time. We have decided to rename it to “Hovmöller plot” instead of diagram to avoid confusion, as in recent times this plot has been used to show the behavior of a variable by latitude and time. We have also characterised it as a “Hovmöller type plot (7A & B)...” in the beginning of section 3.4. Another reason to keep the reference to Hovmöller is that we have used this terminology across the various iterations of the paper throughout the revision and review process, so we have decided to keep it with a slightly amended name for the shake of consistency.

L500: Well, the anomalies in Fig 7C seem largely constrained to be within +/- 60degrees, which is not exactly “equatorial”.

Response: - We have modified the sentence to better characterize this.

“Fig. 7C shows that the latitudinal anomaly of the lower stratosphere warming was centered along the equator and largely constrained 60N-60S.”

L503: The impact of volcanic forcing on tropospheric dynamics through the stratospheric temperature gradient has become more controversial in recent years, see e.g., <https://acp.copernicus.org/articles/20/13687/2020/acp-20-13687-2020.html>. I don't think a citation or discussion is needed here, just perhaps a softening of the language to better reflect the lack of consensus on this issue.

Response: - We modified the sentence and included this as reference for scant evidence.

“Lower stratosphere warming is also thought to affect the northern hemisphere atmospheric circulations, though efforts to confirm the mechanisms and consistency of this response are ongoing (e.g., Graf et al., 1993, 2007; Shindell et al., 2004; Polvani and Camargo 2020).”

Polvani, L. M. and Camargo, S. J.: Scant evidence for a volcanically forced winter warming over Eurasia following the Krakatau eruption of August 1883, Atmos. Chem. Phys., 20, 13687–13700, <https://doi.org/10.5194/acp-20-13687-2020>, 2020.

L507: Courser than what?

Response: - we have changed our phrasing to now read: “we used a relatively coarse resolution model”

L508: what kind of changes is it successful in simulating? Response to volcanic forcing? Or GHGs? Or something else?

Response: - We have modified this sentence for the introduction of GISS modelE and added relevant references.

“We used a relatively coarse resolution earth system model having a simplified parameterization that is skilled in simulating the large-scale patterns of climate response to natural and anthropogenic forcings (Kelley et al., 2020; Miller et al., 2021; Nazarenko et al., 2022)”

Refs:

Larissa S. Nazarenko, Nick Tausnev, Gary L. Russell, David Rind, Ron L. Miller, Gavin A. Schmidt, Susanne E. Bauer, Maxwell Kelley, Reto Ruedy, Andrew S. Ackerman, Igor Aleinov, Michael Bauer, Rainer Bleck, Vittorio Canuto, Grégory Cesana, Ye Cheng, Thomas L. Clune, Ben I. Cook, Carlos A. Cruz, Anthony D. Del Genio, Gregory S. Elsaesser, Greg Faluvegi, Nancy Y. Kiang, Daehyun Kim, Andrew A. Lacis, Anthony Leboissetier, Allegra N. LeGrande, Ken K. Lo, John Marshall, Elaine E. Matthews, Sonali McDermid, Keren Mezuman, Lee T. Murray, Valdar Oinas, Clara Orbe, Carlos Pérez García-Pando, Jan P. Perlwitz, Michael J. Puma, Anastasia Romanou, Drew T. Shindell, Shan Sun, Kostas Tsigaridis, George Tselioudis, Ensheng Weng, Jingbo Wu, Mao-Sung Yao, *Future Climate Change Under SSP Emission Scenarios With GISS-E2.1, Journal of Advances in Modeling Earth Systems*, 10.1029/2021MS002871, 14, 7, (2022).

Miller, R. L., Schmidt, G. A., Nazarenko, L. S., Bauer, S. E., Kelley, M., Ruedy, R., Russell, G. L., Ackerman, A. S., Aleinov, I., Bauer, M., Bleck, R., Canuto, V., Cesana, G., Cheng, Y., Clune, T. L., Cook, B. I., Cruz, C. A., Del Genio, A. D., Elsaesser, G. S., Faluvegi, G., Kiang, N. Y., Kim, D., Lacis, A. A., Leboissetier, A., LeGrande, A. N., Lo, K. K., Marshall, J., Matthews, E. E., McDermid, S., Mezuman, K., Murray, L. T., Oinas, V., Orbe, C., Pérez García-Pando, C., Perlwitz, J. P., Puma, M. J., Rind, D., Romanou, A., Shindell, D. T., Sun, S., Tausnev, N., Tsigaridis, K., Tselioudis, G., Weng, E., Wu, J., and Yao, M. S.: *CMIP6 Historical Simulations (1850–2014) With GISS-E2.1, J. Adv. Model. Earth Sy.*, 13, e2019MS002034, <https://doi.org/10.1029/2019MS002034>, 2021.

L520: See comment on Hovmoeller above.

Response: - modified as per previous comment

L524: Hovmoeller

Response: - modified as per previous comment

L529: This looks less like a trend than a persistent negative anomaly

Response: - we have modified this sentence as given below (Line 540).

“A robust negative anomaly on the order of 0.3-0.4 mm/day in the northern hemisphere rain belt (ITCZ) region appeared during the next year following E1, with a persistent negative anomaly in the subsequent years (Fig. 8)”

L532: at the equator

Response: - Corrected. Line 566.

L641: The usual multiplier for a 95% CI is $1.96 \cdot \sigma$, not 1.95.

Response: - yes, it is approximately 1.96. We used 1.95 as suggested by one of the reviewers during the review process.

L642: Are the values in the table the ensemble standard deviation and ensemble mean?
Table 2: the “Change/Std” labels in the column heading could be interpreted as meaning the values are divided by (normalized by) the standard deviations, which I think is not the case. Please modify the column headings to avoid potential misunderstanding.

Response: - We have modified it according to the values tabulated here as $\text{Change} \pm \text{Std}$.

Fig 11: use lowercase k in “km” in label to colorbar

Response: - Corrected

L692: use degree symbols in latitude rages

Response: - Corrected

L732: ensemble members

Response: - Corrected

L759: the eruptions aren’t identified, I would suggest “detected”

Response: - Corrected

L838: ensemble members

Response: - Corrected

L854: “driving”?

Response: We have changed this to “bringing” for greater clarity.

L871: “on request to the corresponding author”?

Response: - corrected

Fig S1: what quantity is shown in the plots, is it changes in fractional area covered by each plant type?

Response: - We have modified the figure caption to include the details of quantity.

Fig S3: Please indicate in the caption here that these are arbitrarily chosen locations.

Response: - Modified to include this information.

Fig S6: This plot has a distracting patterning of the stippling which should be redrawn.

Response: - We have modified the plot by redrawing the stippling in the manner used for the rainfall plot.